

PRELIMINARY DATA SUMMARY

April 1993

U.S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center
Field Research Facility
Duck, North Carolina

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CERC Field Research Facility
Duck, North Carolina

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

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PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.6 m above the National Geodetic Vertical Datum (NGVD) of the year 1929. In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

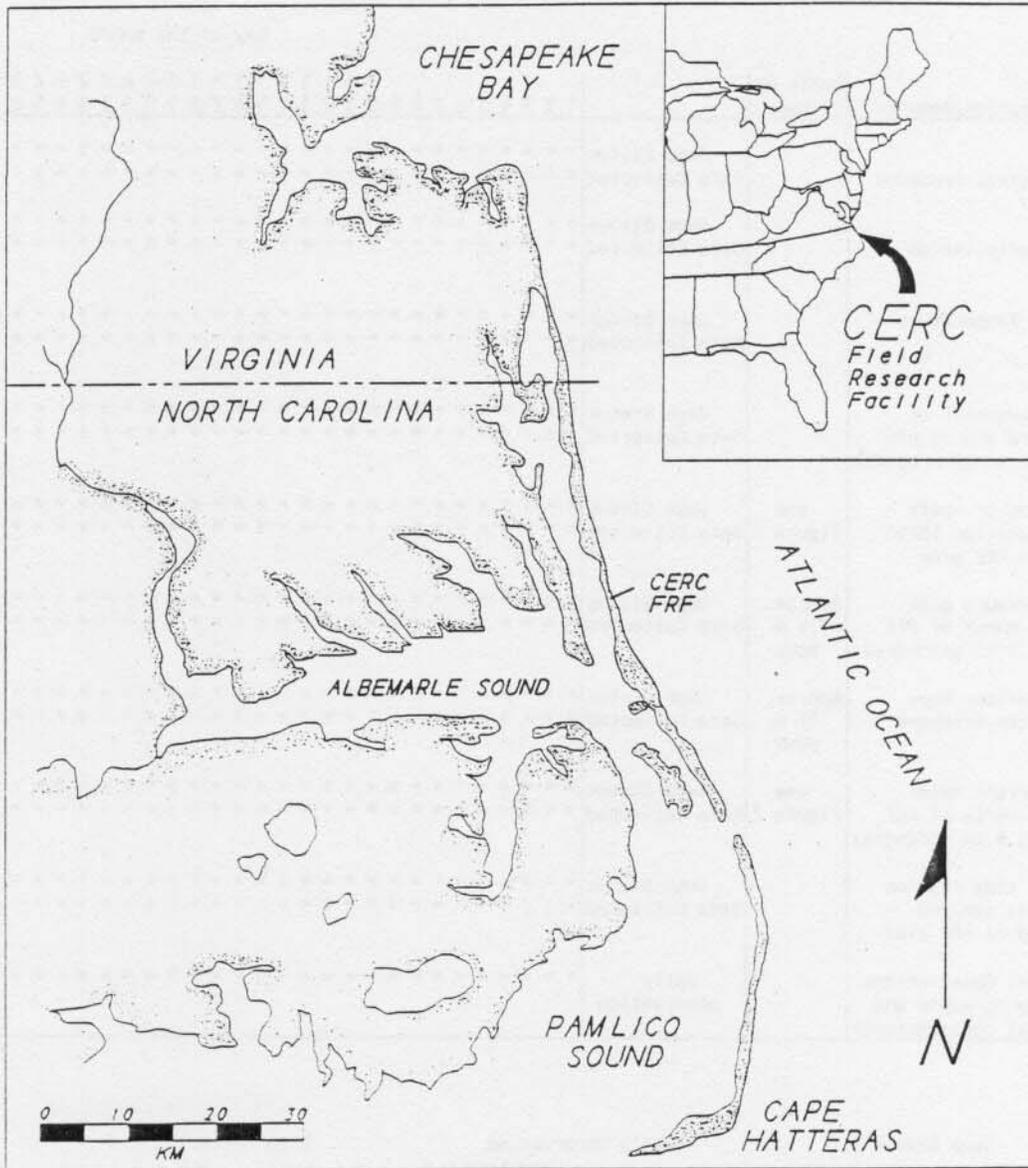


Figure 1. FRF Location Map

Table 1: Instrument Status/Data Availability

April 1993

Gage ID	Description/Remarks	Depth at Sensor		Day of the month																														
				1	2	3	4	5	6	7	8	9	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3				
616	Barometric Pressure		Gage Status	*																														
			Data Collected	*																														
604	Precipitation		Gage Status	*																														
			Data Collected	*																														
624	Air Temperature		Gage Status	*																														
			Data Collected	*																														
932	Anemometer at seaward end of pier Elevation 19 m (NGVD)		Gage Status	*																														
			Data Collected	*																														
625	Baylor staff at station 18+60 on FRF pier	see Figure 7	Gage Status	*																														
			Data Collected	*																														
511	Pressure gage 243 m north of FRF pier (0.9 km offshore)	Approx. 7.9 m NGVD	Gage Status	*																														
			Data Collected	*																														
630	Waverider buoy 4.0 km offshore	Approx. 17 m NGVD	Gage Status	*																														
			Data Collected	*																														
519	Current meter 320 m north of FRF pier (0.9 km offshore)	see Figure 7	Gage Status	*																														
			Data Collected	*																														
865-1370	NOAA tide station at seaward end of FRF pier		Gage Status	*																														
			Data Collected	*/																														
Supplemental Observations (daily oceanographic and meteorological observations)			Daily observation	*																														

Gage Status
 Operational = *
 Partial = /
 Non-Operational = -

Daily Observation
 Complete = *
 Partial = /
 None = -

Data Collected
 All = *
 Partial = /
 None = -

True North

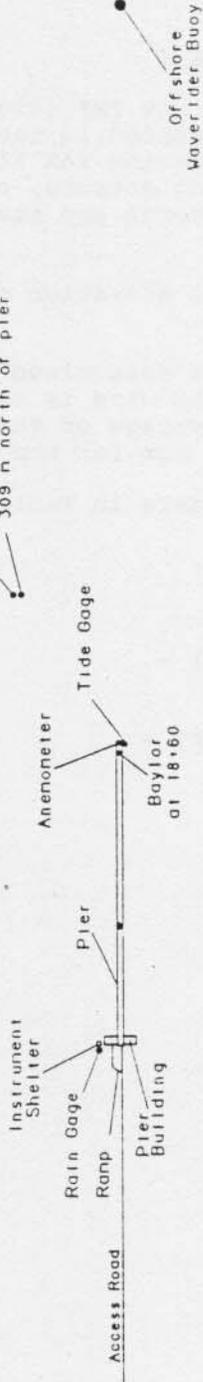
Pier Building at 0+40 to 1+00

12 inch Rain Gage at 0+30

Instrument Shelter at 0+40

Current Meter
320 n north of pier

Pressure Gage
309 n north of pier



CURRITUCK SOUND

ATLANTIC OCEAN

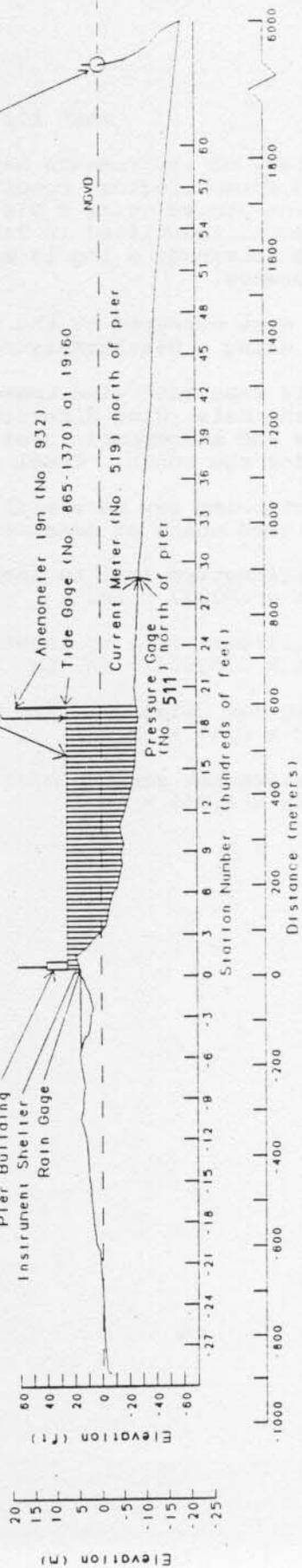


Figure 2. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).

PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 2) using a WeatherMeasure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -
 $\text{m/s} \times 1.943 = \text{kn}$

Table 2: Meteorological Data

Apr 1993

Day	Hour	Wind	Wind	Temperature	Atm	Precipitation
		Speed	Direction	deg C	Pressure	mm
		m/sec	deg TN		mb	
1	100	3	294	16.5	1004.0	0
	700	3	293	17.9	1002.3	0
	1300	8	198	24.4	999.9	0
	1900	9	183	17.9	999.6	0
2	100	3	240	14.8	1001.7	0
	700	5	199	14.8	1003.1	0
	1300	7	239	20.7	1002.3	0
	1900	5	250	16.9	1003.9	0
3	100	6	345	8.8	1009.0	0
	700	8	344	8.5	1015.7	0
	1300	6	23	8.8	1017.4	0
	1900	5	142	7.6	1018.4	0
4	100	2	95	7.4	1020.1	0
	700	6	42	7.5	1021.2	0
	1300	3	81	10.2	1021.0	0
	1900	6	83	6.9	1021.0	0
5	100	7	78	6.5	1019.8	0
	700	9	63	6.9	1018.9	0
	1300	11	49	7.2	1018.1	0
	1900	13	52	6.9	1014.2	12
6	100	14	32	7.7	1009.7	12
	700	17	25	7.5	1009.2	13
	1300	15	9	7.2	1011.1	5
	1900	16	2	5.5	1014.8	6
7	100	15	354	6.0	1015.7	0
	700	14	357	6.2	1016.7	0
	1300	14	352	8.3	1018.0	0
	1900	9	354	7.0	1018.4	0
8	100	9	1	7.2	1016.2	0
	700	8	346	8.0	1018.6	0
	1300	9	347	9.3	1017.3	0
	1900	7	354	7.9	1017.0	0
9	100	3	34	6.5	1016.1	0
	700	4	16	7.8	1015.0	0
	1300	2	17	9.8	1012.9	0
	1900	5	51	9.1	1009.0	0
10	100	4	141	9.9	1004.1	0
	700	6	109	12.2	998.4	3
	1300	6	255	18.1	997.4	0
	1900	8	302	15.0	1000.9	0
11	100	5	285	11.8	1004.7	0
	700	6	278	10.8	1008.5	0
	1300	5	284	18.1	1008.4	0
	1900	3	153	10.5	1007.2	0
12	100	6	202	14.3	1004.7	0
	700	4	339	11.3	1006.5	0
	1300	4	58	16.0	1005.8	0
	1900	3	7	10.5	1008.5	0
13	100	9	334	12.4	1009.2	0
	700	7	349	9.9	1012.6	0
	1300	9	23	10.3	1013.2	0
	1900	3	113	8.9	1013.3	0
14	100	4	222	10.0	1014.1	0
	700	3	150	11.9	1014.8	0
	1300	6	139	15.7	1014.7	0
	1900	7	154	11.5	1014.0	0
15	100	6	186	15.3	1014.3	0
	700	5	165	18.0	1015.5	0
	1300	11	177	24.1	1014.9	0
	1900	10	169	19.8	1013.6	0
16	100	10	153	17.3	1011.8	0
	700	9	180	19.3	1011.8	0
	1300	15	165	22.1	1007.6	0
	1900	10	172	18.0	1005.0	9

* electronic problems

(Continued)

(Sheet 1 of 2)

Table 2: Meteorological Data

Apr 1993

Day	Hour	Wind	Wind	Temperature	Atm	Precipitation
		Speed	Direction	deg C	Pressure	mm
		m/sec	deg TN		mb	
17	100	9	244	16.5	1004.5	0
	700	8	273	13.8	1009.1	0
	1300	6	259	17.8	1009.0	0
	1900	6	282	15.2	1010.7	0
18	100	7	343	10.6	1013.9	0
	700	9	355	9.9	1017.1	0
	1300	4	68	12.3	1016.6	0
	1900	4	1	9.5	1016.5	0
19	100	6	206	11.4	1017.9	0
	700	6	231	13.8	1019.6	0
	1300	4	1	19.8	1018.6	0
	1900	8	164	15.9	1017.4	0
20	100	5	186	14.8	1017.4	0
	700	5	199	17.1	1019.4	0
	1300	6	161	22.0	1016.4	0
	1900	10	184	17.8	1015.1	0
21	100	7	185	16.3	1013.6	0
	700	6	192	17.8	1013.3	0
	1300	9	176	23.5	1009.3	0
	1900	8	184	19.1	1005.1	0
22	100	6	200	17.7	1000.6	0
	700	3	11	10.7	1000.0	0
	1300	9	302	8.9	1002.4	0
	1900	7	303	9.1	1005.5	0
23	100	9	281	10.0	1007.4	0
	700	11	273	11.8	1010.0	0
	1300	11	1	17.1	1010.5	0
	1900	3	111	12.0	1014.0	0
24	100	4	209	13.5	1017.0	0
	700	4	218	14.9	1019.7	0
	1300	5	107	17.5	1020.0	0
	1900	9	195	17.9	1019.1	0
25	100	6	189	16.2	1020.9	0
	700	6	200	18.3	1021.9	0
	1300	8	193	25.0	1019.8	0
	1900	11	191	19.3	1018.5	0
26	100	7	194	17.8	1017.2	0
	700	8	190	18.8	1015.7	0
	1300	12	176	22.7	1010.8	0
	1900	4	203	17.1	1009.7	13
27	100	12	352	9.3	1012.9	0
	700	11	355	7.4	1017.9	0
	1300	11	2	8.7	1021.1	0
	1900	10	29	8.5	1023.1	0
28	100	9	7	8.7	1023.6	0
	700	11	8	9.6	1024.1	0
	1300	12	357	11.6	1024.0	0
	1900	9	16	9.0	1022.6	0
29	100	8	355	9.6	1020.9	0
	700	7	351	11.1	1020.7	0
	1300	6	348	13.0	1019.0	0
	1900	4	10	11.0	1018.2	0
30	100	4	12	10.1	1016.8	0
	700	3	339	13.2	1017.4	0
	1300	2	38	15.2	1017.3	0
	1900	2	43	11.9	1016.9	0
			<u>Resultant</u>	<u>Mean</u>	<u>Mean</u>	<u>Total</u>
			1	344	13.0	1013.2
						73

* electronic problems

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PART III: WAVE DATA

Wave data are collected from a Baylor staff gage (Gage 625), a pressure wave gage (Gage 511) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 3 hr. The sampling rate is two times per second for five contiguous 34-min records. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height H_{m0} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all H_{m0} and T_p values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 3: Wave Data

Apr 1993

Day	Hour	625		511		630	
		Baylor at 18+60 Hmo,m	TP,sec	Pressure Gage Hmo,m	TP,sec	Offshr Hmo,m	Wvrdr TP,sec
1	0100	0.72	8.83	0.72	8.53	0.91	9.48
	0700	0.84	6.74	0.98	7.31	1.01	9.14
	1300	0.84	8.00	0.89	8.53	1.12	8.53
	1900	0.76	8.53	0.80	8.53	1.00	9.14
2	0100	0.72	8.83	0.80	10.67	0.88	7.53
	0700	0.73	10.24	0.87	8.00	1.02	10.24
	1300	0.81	9.85	0.89	10.24	0.93	10.24
	1900	0.59	10.24	0.74	10.67	0.82	10.24
3	0100	0.89	8.53	0.97	9.48	1.09	9.14
	0700	0.77	5.33	0.85	5.22	1.01	5.33
	1300	0.71	5.57	0.84	5.57	0.93	5.57
	1900	0.63	5.69	0.70	6.40	0.74	8.53
4	0100	0.52	6.74	0.57	8.83	0.67	5.82
	0700	0.51	9.48	0.51	9.14	0.63	8.83
	1300	0.49	7.53	0.50	8.83	0.57	8.00
	1900	0.69	7.53	0.61	8.53	0.79	7.53
5	0100	0.80	4.00	0.72	3.71	0.86	3.94
	0700	1.01	4.34	0.94	4.41	1.13	4.49
	1300	1.00	4.92	0.98	5.12	1.17	5.02
	1900	1.38	4.92	1.56	5.33	1.68	5.45
6	0100	1.84	6.09	2.08	6.09	2.20	6.56
	0700	2.39	8.00	2.67	6.92	2.89	6.92
	1300	2.68	9.14	3.31	10.24	3.81	10.24
	1900	3.13	11.64	4.11	11.13	4.19	11.13
7	0100	2.42	11.64	3.26	10.67	3.14	11.13
	0700	2.45	10.67	2.77	11.13	2.87	10.24
	1300	2.29	11.13	2.99	10.24	2.95	10.67
	1900	3.08	15.06	3.63	14.22	3.45	14.22
8	0100	2.39	13.47	2.76	14.22	2.51	11.64
	0700	2.62	14.22	2.92	14.22	2.66	13.47
	1300	2.46	14.22	2.62	13.47	2.38	14.22
	1900	2.39	13.47	2.60	13.47	2.47	11.64
9	0100	1.93	12.80	2.02	12.80	1.88	11.64
	0700	1.68	12.19	1.92	12.19	1.80	11.64
	1300	1.40	11.64	1.63	11.64	1.48	11.13
	1900	1.34	11.64	1.45	11.64	1.45	11.64
10	0100	1.05	11.64	1.21	11.13	1.22	11.13
	0700	1.06	10.67	1.15	10.67	1.24	10.24
	1300	1.19	9.85	1.26	9.48	1.40	7.76
	1900	1.06	7.53	1.22	8.53	1.26	7.76
11	0100	0.81	9.85	0.97	9.48	0.99	9.48
	0700	0.74	9.85	0.80	9.85	0.87	9.85
	1300	0.61	9.85	0.69	10.24	0.68	9.48
	1900	0.61	8.83	0.58	9.48	0.69	9.14
12	0100	0.52	15.06	0.53	15.06	0.62	9.48
	0700	0.57	11.64	0.59	11.13	0.65	11.13
	1300	0.63	12.19	0.63	10.67	0.76	10.67
	1900	0.71	12.19	0.81	11.64	0.84	11.64
13	0100	0.78	11.64	0.73	12.19	0.90	11.64
	0700	0.82	13.47	0.90	13.47	0.94	13.47
	1300	0.95	13.47	1.07	13.47	1.09	13.47
	1900	0.86	13.47	0.86	12.80	0.96	12.80
14	0100	0.90	14.22	0.98	13.47	1.01	13.47
	0700	0.87	13.47	1.01	13.47	1.05	13.47
	1300	1.03	12.80	1.08	12.19	1.08	12.80
	1900	1.01	12.80	1.13	10.67	1.21	11.13
15	0100	0.92	12.19	1.04	12.19	1.16	11.64
	0700	0.92	11.64	1.02	12.19	0.99	11.64
	1300	0.87	9.85	1.05	10.24	1.11	10.24
	1900	0.82	9.85	0.94	10.67	0.98	11.13
16	0100	0.86	9.14	0.95	9.14	1.07	11.13
	0700	0.90	8.26	0.95	7.76	1.15	7.53
	1300	1.33	9.85	1.42	9.85	1.48	9.48
	1900	1.05	9.85	1.21	9.48	1.38	10.24

* Electronic problems

(Continued)

(Sheet 1 of 2)

Table 3: Wave Data

Apr 1993

Day	Hour	625 Baylor at 18+60		511 Pressure Gage		630 Offshr Wvrdr	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec
17	0100	0.92	9.48	1.10	9.14	1.20	9.14
	0700	0.86	9.85	0.93	9.48	1.09	10.24
	1300	0.74	9.14	0.87	9.48	0.98	8.53
	1900	0.63	9.14	0.70	9.85	0.86	8.83
18	0100	0.60	9.14	0.62	8.26	0.82	9.48
	0700	0.72	5.12	0.83	5.12	1.32	5.33
	1300	0.49	7.11	0.54	9.14	0.61	9.14
	1900	0.46	8.53	0.45	9.48	0.63	9.85
19	0100	0.38	8.00	0.46	9.14	0.50	7.31
	0700	0.42	7.76	0.45	8.00	0.49	7.76
	1300	0.38	8.00	0.42	7.31	0.47	8.26
	1900	0.42	7.76	0.43	8.83	0.63	7.11
20	0100	0.44	8.26	0.48	8.53	0.57	7.76
	0700	0.41	8.00	0.47	7.76	0.51	8.26
	1300	0.43	7.76	0.46	7.53	0.52	7.53
	1900	0.47	15.06	0.48	15.06	0.59	8.26
21	0100	0.42	15.06	0.54	14.22	0.53	14.22
	0700	0.49	13.47	0.50	14.22	0.54	14.22
	1300	0.51	12.80	0.55	13.47	0.61	13.47
	1900	0.61	13.47	0.57	12.80	0.74	12.19
22	0100	0.61	8.00	0.66	12.80	0.70	13.47
	0700	0.72	9.14	0.76	8.83	0.85	9.14
	1300	0.71	8.26	0.80	9.85	0.99	4.66
	1900	0.72	5.02	0.81	9.14	1.00	5.12
23	0100	0.39	9.48	0.45	9.14	0.56	5.95
	0700	0.35	9.85	0.39	16.00	0.58	2.25
	1300	0.36	16.00	0.35	16.00	0.61	2.37
	1900	0.38	16.00	0.44	15.06	0.38	16.00
24	0100	0.29	16.00	0.34	16.00	0.34	16.00
	0700	0.32	15.06	0.33	15.06	0.42	15.06
	1300	0.31	15.06	0.37	15.06	0.40	15.06
	1900	0.44	15.06	0.47	15.06	0.71	15.06
25	0100	0.32	14.22	0.37	15.06	0.42	15.06
	0700	0.37	13.47	0.38	13.47	0.44	14.22
	1300	0.41	14.22	0.42	14.22	0.58	14.22
	1900	0.52	14.22	0.50	14.22	1.04	13.47
26	0100	0.44	14.22	0.47	6.92	0.52	6.40
	0700	0.44	13.47	0.46	13.47	0.57	14.22
	1300	0.72	13.47	0.67	3.66	0.90	3.77
	1900	0.62	6.56	0.67	6.92	0.88	6.74
27	0100	1.01	5.12	1.09	4.92	1.45	5.12
	0700	1.70	5.95	1.99	5.95	2.24	6.40
	1300	1.93	8.53	2.20	8.83	2.28	8.53
	1900	1.87	10.24	1.97	9.85	2.29	7.11
28	0100	1.73	11.13	1.89	11.13	1.81	11.13
	0700	1.91	11.13	2.09	11.13	2.17	11.13
	1300	1.85	11.13	2.05	11.13	2.36	11.64
	1900	1.99	11.13	2.15	10.24	2.25	10.67
29	0100	2.10	11.64	2.31	11.13	2.19	11.64
	0700	1.95	11.13	2.36	11.64	1.98	10.24
	1300	1.90	11.64	2.28	11.13	2.05	11.64
	1900	2.11	11.64	2.25	11.13	2.14	11.13
30	0100	2.00	11.64	2.11	11.64	2.21	10.24
	0700	1.79	11.64	2.01	12.19	1.91	10.67
	1300	1.53	10.67	1.58	9.85	1.70	10.24
	1900	1.26	11.13	1.36	10.24	1.39	10.67
	Mean	1.04	10.44	1.16	10.44	1.25	9.89
	Std dev	0.68	2.93	0.81	2.85	0.77	2.98

* Electronic problems

(Sheet 2 of 2)

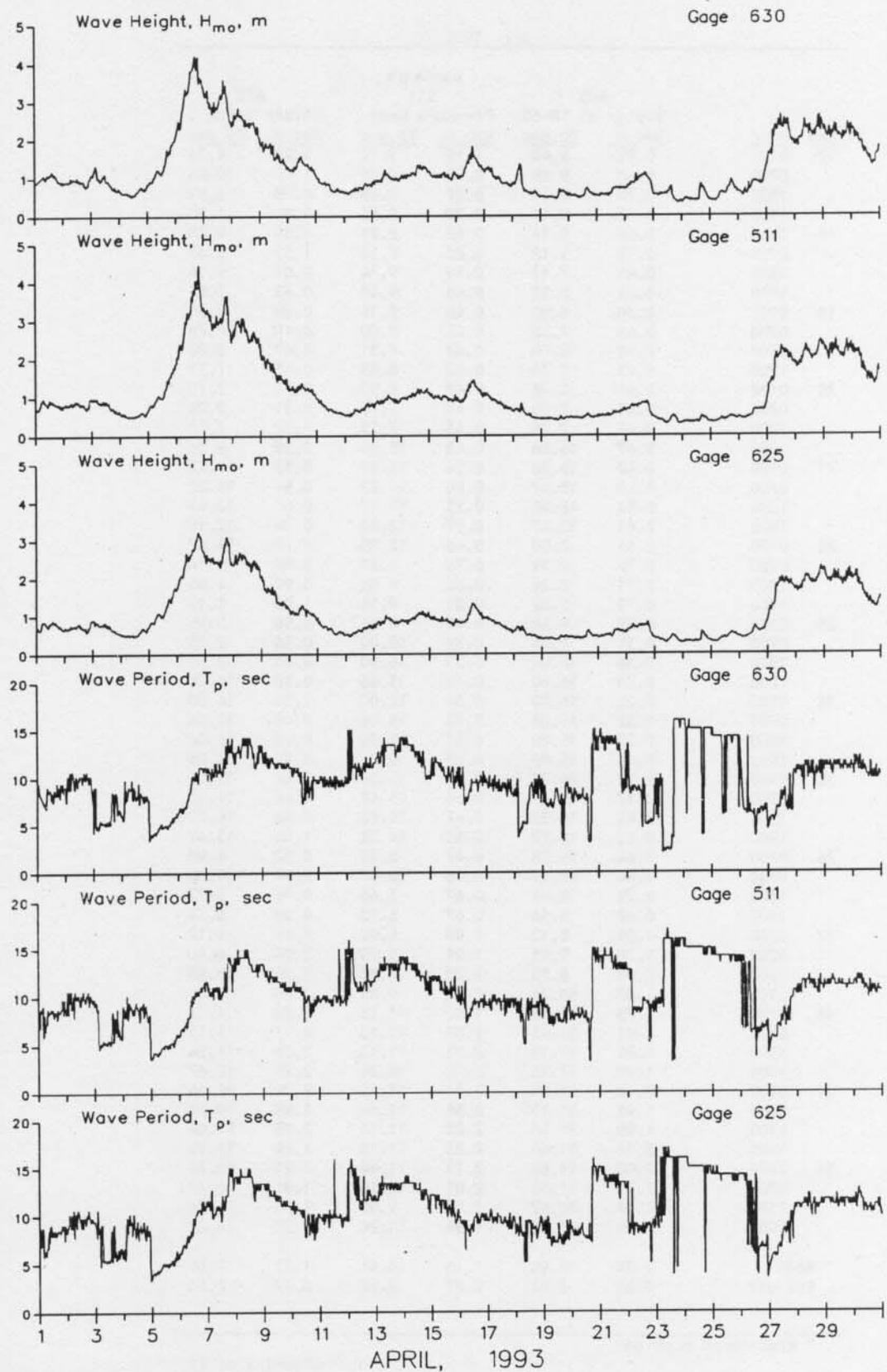


Figure 3. Time history of wave heights and periods

PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward).

All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

IMPORTANT NOTE

Direction resultants regarding the current meter data (gages 519 and 529) may be in error by 5 degrees due to the uncertainty of the orientation. Please call us if you must use this data.

Table 4: Current Data
Apr 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements					Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed Dir		Dye 12m offshore (surface) Location	Speed Dir		Speed	Dir
			Speed	Dir		Speed	Dir		Speed	Dir		
1	0100	Along Cross Result								7 1 7	S off 152	
1	0700	Along Cross Result	20 8 22	N off 2	168	61 6 61	N off 346	South	9 N	5 2 5	S off 140	
1	1300	Along Cross Result								8 0 8	S 160	
1	1900	Along Cross Result								10 1 10	S on 168	
2	0100	Along Cross Result								1 1 2	N on 290	
2	0700	Along Cross Result	0 0 0		152	61 12 62	N off 351	South	15 N	11 3 11	S off 143	
2	1300	Along Cross Result								11 3 11	S off 144	
2	1900	Along Cross Result								19 16 24	S off 120	
3	0100	Along Cross Result								29 14 32	S off 135	
3	0700	Along Cross Result	76 4 76	S on 163	164	68 0 68	S 160	North	24 S	48 16 50	S off 141	
3	1300	Along Cross Result								40 15 42	S off 139	
3	1900	Along Cross Result								26 14 29	S off 131	
4	0100	Along Cross Result								37 3 37	S off 155	
4	0700	Along Cross Result	23 6 23	S on 174	165	18 6 20	S on 179	North	8 N	34 19 39	S off 130	
4	1300	Along Cross Result								28 13 30	S off 135	
4	1900	Along Cross Result								27 16 31	S off 129	
5	0100	Along Cross Result								10 5 11	S off 132	
5	0700	Along Cross Result	0 0 0		165	0 0 0		North	8 N	14 10 17	S off 123	
5	1300	Along Cross Result								19 10 21	S off 133	
5	1900	Along Cross Result								32 14 35	S off 137	

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1993

Day	Time	Alongshore Cross-shore Resultant ---- Time	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519			
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir		
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed			Dir	
6	0100	Along Cross Result								34	S		
										14	off		
										36	137		
6	0700	Along Cross Result	55	S	177	28	S	North	6	N	55	S	
			6	on		6	on					20	off
			56	166		28	171					58	140
6	1300	Along Cross Result									63	S	
											26	off	
											68	137	
6	1900	Along Cross Result									93	S	
											28	off	
											97	143	
7	0100	Along Cross Result									87	S	
											18	off	
											89	148	
7	0700	Along Cross Result	102	S	165	102	S	North	50	S	69	S	
			20	on		5	off					15	off
			104	171		102	157					71	148
7	1300	Along Cross Result									79	S	
											25	off	
											83	143	
7	1900	Along Cross Result									36	S	
											16	off	
											39	136	
8	0100	Along Cross Result									47	S	
											11	off	
											49	146	
8	0700	Along Cross Result	102	S	167	76	S	North	22	S	20	S	
			20	on		8	off					10	off
			104	171		77	154					22	133
8	1300	Along Cross Result									48	S	
											13	off	
											50	145	
8	1900	Along Cross Result									33	S	
											15	off	
											37	135	
9	0100	Along Cross Result									40	S	
											20	off	
											45	134	
9	0700	Along Cross Result	36	S	165	76	N	North	26	S	8	S	
			0	on		11	off					4	off
			36	160		77	349					8	136
9	1300	Along Cross Result									25	S	
											21	off	
											33	119	
9	1900	Along Cross Result									26	S	
											20	off	
											33	122	
10	0100	Along Cross Result									16	S	
											19	off	
											25	112	
10	0700	Along Cross Result	29	N	165	68	N	South	29	N	11	S	
			6	off		20	on					0	
			30	351		71	323					11	160
10	1300	Along Cross Result									14	S	
											3	off	
											14	149	
10	1900	Along Cross Result									1	S	
											1		
											1	160	

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
 S = Southward, Shore parallel
 on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1993

Day	Time	Alongshore Cross-shore Resultant ---- Time	Pier Measurements					Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface) Distance from Baseline		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	(m)	Speed	Dir	Location	Speed			Dir
11	0100	Along Cross Result									11 30 32	S off 89
11	0700	Along Cross Result	32 32 45	S off 115	165	21 6 22	S off 143		North	6 S	14 4 14	S on 176
11	1300	Along Cross Result									18 14 23	S off 122
11	1900	Along Cross Result									26 11 28	S off 138
12	0100	Along Cross Result									25 2 25	S off 156
12	0700	Along Cross Result	36 2 36	S off 157	168	24 5 25	N off 351		South	4 S	20 12 23	S off 129
12	1300	Along Cross Result									19 8 20	S off 138
12	1900	Along Cross Result									4 8 9	S off 95
13	0100	Along Cross Result									1 5 5	S off 83
13	0700	Along Cross Result	55 0 55	S on 160	165	23 7 24	S off 143		North	5 S	38 9 39	S off 146
13	1300	Along Cross Result									41 13 43	S off 143
13	1900	Along Cross Result									36 14 39	S off 139
14	0100	Along Cross Result									37 14 39	S off 139
14	0700	Along Cross Result	41 6 41	S on 169	165	23 14 26	N off 11		South	5 N	33 10 34	S off 142
14	1300	Along Cross Result									14 5 15	S off 139
14	1900	Along Cross Result									14 1 14	S on 162
15	0100	Along Cross Result									6 2 6	N on 321
15	0700	Along Cross Result	41 6 41	S on 169	165	23 14 26	N off 11		South	5 N	1 0 1	N on 340
15	1300	Along Cross Result									13 2 13	N on 333
15	1900	Along Cross Result									3 4 4	S on 213

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface) Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location	Speed	Dir	Speed
16	0100	-Along Cross Result								17 8 19	N on 316
16	0700	-Along Cross Result	27 0 27	N off 340	152	102 25 105	N off 354	South	13	15 10 18	N on 307
16	1300	-Along Cross Result								27 6 27	N on 328
16	1900	-Along Cross Result								25 6 25	N on 325
17	0100	-Along Cross Result								20 12 23	N on 308
17	0700	-Along Cross Result	47 14 49	N off 357	165	87 0 87	N off 340	South	38	7 3 8	N on 319
17	1300	-Along Cross Result								9 2 10	N on 326
17	1900	-Along Cross Result								2 4 4	S off 95
18	0100	-Along Cross Result								18 8 20	S off 135
18	0700	-Along Cross Result	8 8 11	S off 115	165	44 33 54	N off 17	South	8	51 17 53	S off 142
18	1300	-Along Cross Result								49 20 53	S off 138
18	1900	-Along Cross Result								33 6 33	S off 150
19	0100	-Along Cross Result								8 1 8	S off 151
19	0700	-Along Cross Result	102 0 102	S off 160	152	34 0 34	S off 160	North	22	8 2 8	S off 146
19	1300	-Along Cross Result								3 4 5	S off 110
19	1900	-Along Cross Result								5 1 5	N on 329
20	0100	-Along Cross Result								10 2 10	N on 329
20	0700	-Along Cross Result	0 0 0	off 0	142	4 7 8	N off 38	South	4	6 2 7	N on 321
20	1300	-Along Cross Result								10 5 11	N on 317
20	1900	-Along Cross Result								18 6 19	N on 322

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Apr 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements					Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed			Dir
21	0100	-Along Cross Result									18 6 19	N on 321
21	0700	-Along Cross Result	30 9 32	N off 357	165	22 12 25	N off 9	South	7	N	13 5 13	N on 320
21	1300	-Along Cross Result									11 4 12	N on 318
21	1900	-Along Cross Result									21 5 22	N on 327
22	0100	-Along Cross Result									11 8 13	N on 304
22	0700	-Along Cross Result	28 8 29	N off 357	155	34 7 35	N off 351	South	10	N	6 3 7	N on 314
22	1300	-Along Cross Result									17 5 18	S off 144
22	1900	-Along Cross Result									24 7 25	S off 144
23	0100	-Along Cross Result									22 8 23	S off 141
23	0700	-Along Cross Result	12 12 17	S off 115	154	14 9 17	N off 13	South	6	N	11 0 11	S on 160
23	1300	-Along Cross Result									12 3 12	S off 144
23	1900	-Along Cross Result									18 14 23	S off 122
24	0100	-Along Cross Result									9 1 9	S on 166
24	0700	-Along Cross Result	61 21 65	S off 141	152	16 10 19	S off 127	North	0		8 3 8	N off 359
24	1300	-Along Cross Result									8 6 10	S off 126
24	1900	-Along Cross Result									0 5 5	on 250
25	0100	-Along Cross Result									7 2 7	N on 322
25	0700	-Along Cross Result	5 6 8	N off 31	152	0 0 0	0	South	3	N	5 3 6	N on 308
25	1300	-Along Cross Result									0 4 4	on 250
25	1900	-Along Cross Result									28 8 29	N on 325

KEY = All speeds in cm/sec
N = Northward, Shore parallel
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on = onshore off = offshore

Table 4: Current Data (Concluded)
Apr 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (surface) Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location	Speed	Dir	Speed	Dir
26	0100	-Along Cross Result									17 5 18	N on 324
26	0700	-Along Cross Result	32 18 37	N off 9	155	15 11 19	N off 15	South	12	N	10 6 12	N on 310
26	1300	-Along Cross Result									12 2 13	N on 329
26	1900	-Along Cross Result									14 6 15	N on 319
27	0100	-Along Cross Result									17 6 18	S off 140
27	0700	-Along Cross Result	38 10 39	N off 354	152	36 14 39	N off 2	South	18	N	49 15 51	S off 143
27	1300	-Along Cross Result									52 19 55	S off 140
27	1900	-Along Cross Result									72 26 76	S off 140
28	0100	-Along Cross Result									56 21 60	S off 140
28	0700	-Along Cross Result	68 14 69	S off 149	163	122 6 122	S off 157	North	82	S	52 18 55	S off 141
28	1300	-Along Cross Result									52 11 53	S off 148
28	1900	-Along Cross Result									42 16 45	S off 139
29	0100	-Along Cross Result									24 15 28	S off 128
29	0700	-Along Cross Result	68 7 68	S on 166	163	122 6 122	S on 163	North	39	S	22 7 23	S off 144
29	1300	-Along Cross Result									34 13 37	S off 140
29	1900	-Along Cross Result									38 13 40	S off 142
30	0100	-Along Cross Result									11 2 11	S on 172
30	0700	-Along Cross Result	61 6 61	S off 154	165	76 11 77	S on 169	North	11	S	17 7 19	S off 137
30	1300	-Along Cross Result									19 10 22	S off 133
30	1900	-Along Cross Result									10 4 10	S off 140

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 5: Supplemental Observations

Apr 1993

Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End		
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0800	80	130		144	6.6	1.0223	0.6
2	0910	85			82	7.0	1.0249	1.8
3	1005	40		80	160	8.7	1.0160	0.9
4	0950	40		75	115	8.5	1.0149	1.2
5	0730	70		80	155	8.9	1.0153	0.9
6	0955	60		60	354	8.3	1.0150	0.3
7	0745	65	15	55	366	7.5	1.0162	0.3
8	0750	75		80	317	7.8	1.0175	0.3
9	0730	75	15	80	232	8.2	1.0178	0.6
10	1050	85		65	153	8.9	1.0175	1.2
11	0845	70	15	85	92	9.2	1.0169	0.9
12	0720	25			113	9.8	1.0170	1.8
13	0715	30		75	136	10.0	1.0170	0.9
14	0720	85			141	9.9	1.0159	1.2
14	0720	85			141	9.9	1.0159	1.2
15	0730	80	145		98	8.7	1.0215	1.5
16	0720	105		100	104	7.5	1.0246	1.2
17	0825	80			117	6.7	1.0262	1.2
18	0920	20		60	49	10.3	1.0185	0.9
19	0706	75			61	9.2	1.0218	1.2
20	0705	80			5	8.6	1.0236	1.2
21	0900	75	120		68	7.4	1.0255	1.2
22	0820	75	150		84	7.1	1.0254	0.9
23	0710	none	visible		7	8.8	1.0216	1.2
24	0945	none	visible		2	9.9	1.0223	1.2
25	0815	75	125		2	8.1	1.0248	0.9
26	0745	85	120		9	7.9	1.0254	1.5
27	0845	35		45	158	7.2	1.0260	0.3
28	0850	60		60	324	10.6	1.0187	0.3
29	0750	70		65	301	10.3	1.0190	0.3

PART VI: WATER LEVELS

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gage is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

Table 6: Water Levels,m NGVD

		Apr 1993			
Mid-Cycle	Low	High	Mean	Range	
Day	Time				
1	642	-0.14	0.79	0.33	0.93
1	1907	-0.16	0.69	0.29	0.86
2	732				
2	1957	Gage Inoperative			
3	822				
3	2048	-0.42	0.78	0.19	1.21
4	913	-0.48	0.75	0.15	1.23
4	2138	-0.48	0.89	0.19	1.37
5	1003	-0.48	0.82	0.20	1.30
5	2228	-0.24	1.15	0.47	1.39
6	1054	-0.12	1.16	0.54	1.29
6	2319	-0.24	1.42	0.59	1.66
7	1144	-0.32	1.07	0.42	1.39
8	9	-0.41	1.29	0.42	1.70
8	1234	-0.44	0.86	0.21	1.30
9	100	-0.45	1.10	0.30	1.56
9	1325	-0.45	0.74	0.16	1.19
10	150	-0.27	1.05	0.36	1.32
10	1415	-0.26	0.88	0.27	1.14
11	240	-0.27	0.96	0.33	1.23
11	1506	-0.16	0.67	0.26	0.83
12	331	-0.18	0.86	0.33	1.05
12	1556	-0.12	0.62	0.26	0.74
13	421	-0.07	0.77	0.34	0.84
13	1646	-0.06	0.66	0.32	0.73
14	512	-0.07	0.72	0.32	0.79
14	1737	-0.07	0.63	0.27	0.71
15	602	-0.15	0.64	0.25	0.79
15	1827	-0.14	0.59	0.23	0.73
16	652	-0.33	0.61	0.20	0.94
16	1917	-0.18	0.66	0.23	0.84
17	743	-0.20	0.59	0.18	0.80
17	2008	-0.21	0.65	0.23	0.86
18	833	-0.20	0.66	0.22	0.86
18	2058	-0.34	0.65	0.14	0.98
19	923	-0.39	0.45	0.04	0.84
19	2149	-0.45	0.59	0.07	1.04
20	1014	-0.48	0.41	-0.03	0.89
20	2239	-0.52	0.58	0.02	1.10
21	1104	-0.48	0.38	-0.01	0.86
21	2329	-0.34	0.72	0.19	1.06
22	1155	-0.26	0.65	0.20	0.91
23	20	-0.39	0.88	0.23	1.27
23	1245	-0.48	0.42	0.00	0.90
24	110	-0.57	0.69	-0.01	1.26
24	1335	-0.58	0.39	-0.11	0.96
25	201	-0.58	0.56	-0.05	1.14
25	1426	-0.56	0.29	-0.12	0.85
26	251	-0.65	0.38	-0.16	1.04
26	1516	-0.49	0.50	-0.07	0.99
27	341	-0.15	0.69	0.26	0.84
27	1607	0.05	0.83	0.45	0.78
28	432	-0.09	0.94	0.39	1.03
28	1657	0.03	0.81	0.40	0.78
29	522	-0.05	0.93	0.40	0.98
29	1747	-0.08	0.74	0.36	0.82
30	613	-0.25	0.85	0.30	1.10
30	1838	-0.17	0.72	0.28	0.89

FRF Tide Heights

Apr 1993

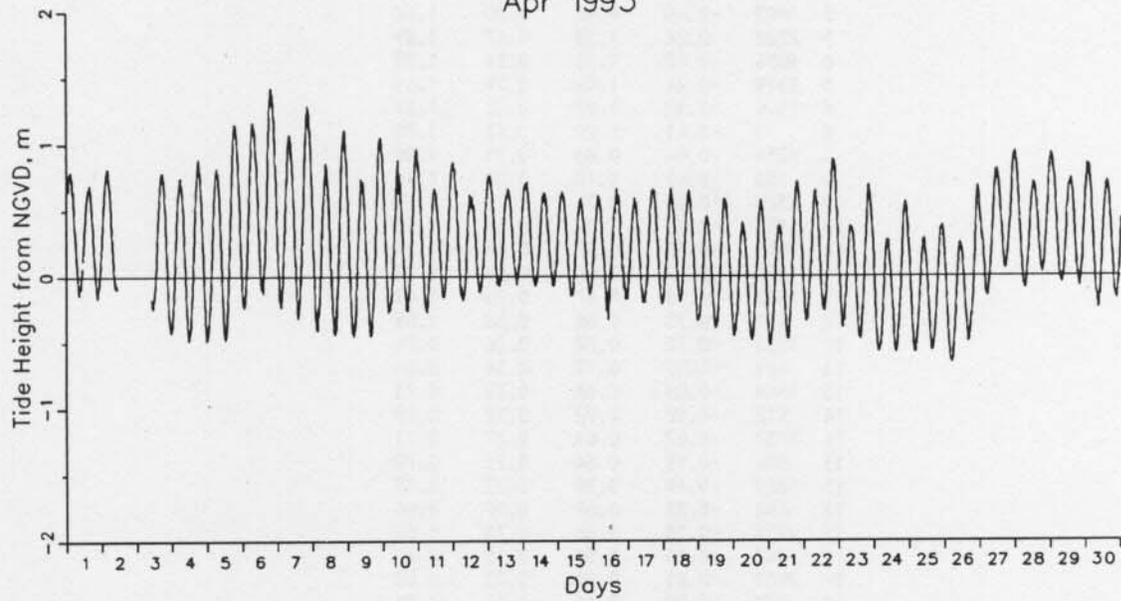


Figure 4. Water level time history

Monthly Water Levels, m NGVD
Extreme Low = -0.65 on day 26 at 418 EST
Extreme High = 1.42 on day 6 at 1854 EST
Monthly Mean = 0.22
Mean Low = -0.29
Mean High = 0.74
Mean Range = 1.03

PART VII: NEARSHORE PROFILES

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in March 1993 and the surveys in April 1993 on profile line 188, located 517 m south of the pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in April.

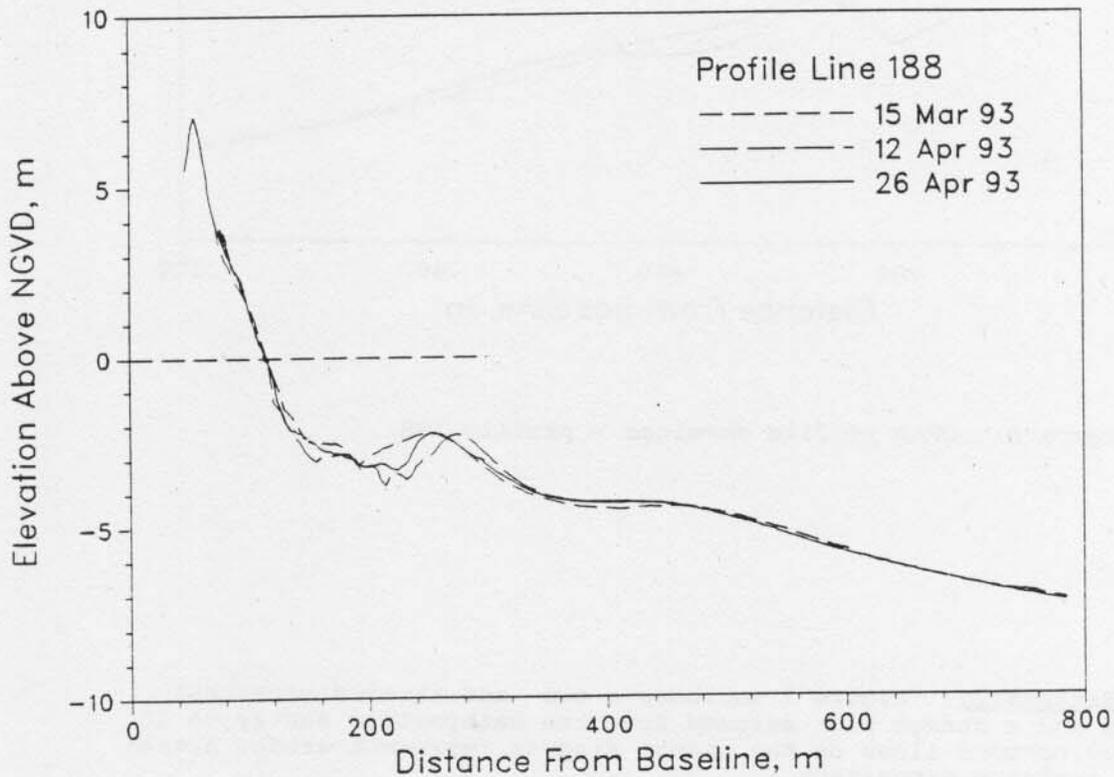


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

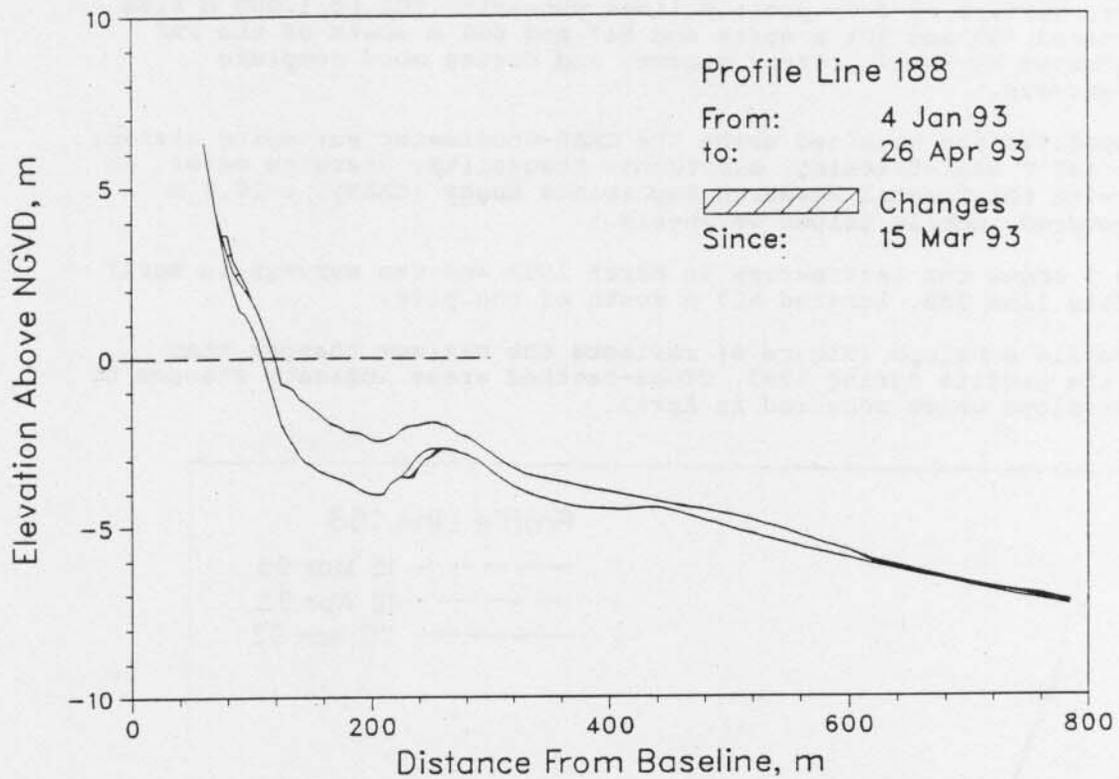
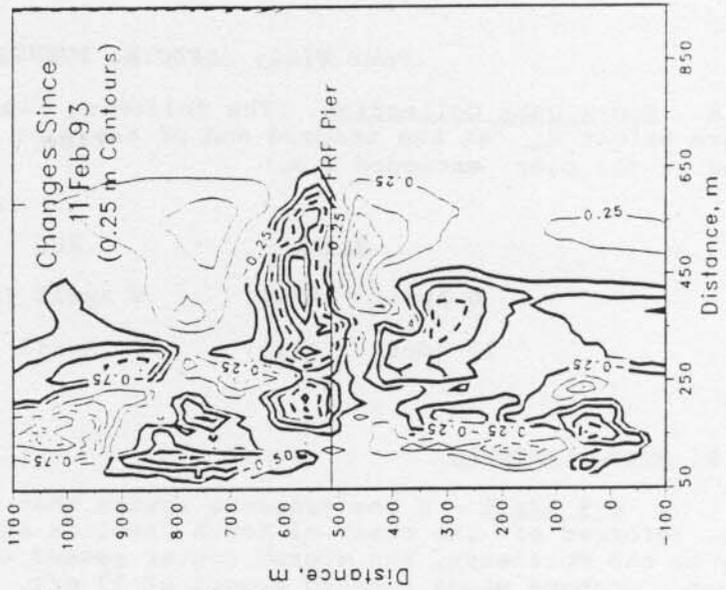
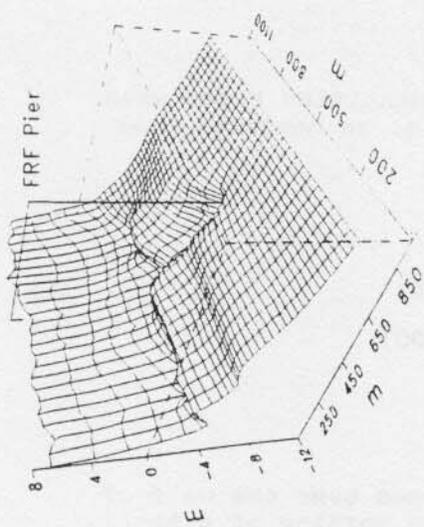


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 16 March. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

Figure 7 is included for reference. There was no complete survey in April.



PART VIII. SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m.

<u>Start</u>	<u>End</u>
6 April (0245)	9 April (0016)
27 April (1216)	30 April (0400)

B. Storm Synopsis.

6-9 April - A low pressure system that formed over the Gulf of Mexico, reformed off the coast of South Carolina on the morning of 6 April. Moving to the Northeast, the storm's center passed about 40km south of Cape Hatteras. Onshore winds reached speeds of 17 m/s. Waves at gage 630 reached a maximum H_{mo} of 4.2 m ($T_p = 9.8$ s) on 6 April at 1634 EST. Atmospheric pressure was unaffected. There was 42 mm of precipitation.

27-30 April - Northerly winds associated with a high pressure system over Quebec, reached 12.8 m/s at 1142 EST on 28 April. Waves at gage 625 reached a maximum H_{mo} of 2.3 m ($T_p = 11.13$ s) at 2116 EST on 28 April. Atmospheric pressure was unaffected. There was no precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge	U.S. Geological Survey
USACE-OCE	U.S. Library of Congress
USACE-SAD	U.S. National Park Service
USACE-NAP	U.S. National Weather Service
USACE-SAW	U.S. Naval Academy
USACE-WES	U.S. Naval Civil Eng. Lab
NAVSAC	U.S. Naval Oceanographic Off.
NOAA/NOS/OMS	U.S. Naval Research Lab
National Marine Fisheries	

Colleges/Universities:

Bucknell University	Scripps Institution of Oceanography
California Inst. of Tech.	Stockton State College
Duke Marine Lab	University Calif-Berkeley
East Carolina University	University of Florida
Florida Inst. of Tech.	University of Maryland-College Park
M.I.T.	University of Maryland-Baltimore
Naval Post Graduate School	University of North Carolina
NC State University	University of N C-Seagrant Program
Old Dominion University	University of Virginia
Oregon State University	Va. Inst. of Marine Science
Prince George's College	Rutgers University

Others:

Allied Signal Aerospace Co.	WCTI-TV
Applied Physics Lab	MEC Systems Corporation
Cape Hatteras Nat. Seashore	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	N.C. Div. Coastal Management
Coastal Science & Eng., Inc.	Oregon Inlet & Waterways Commission
Dr. Cy Galvin	Raleigh-Durham Airport
GEOMET Tech., Inc.	Mr. Rowland
Mr. Hodges	Mr. Savage
Dr. Hylton	Science Application Int'l. Corp
Mr. Mason	Sherwood Industries
Mr. Rodgers	SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)